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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 :		(11) International Publication Number:
B01D 39/20, 29/21	A1	WO 00/45937
		(43) International Publication Date: 10 August 2000 (10.08.00)

(21) International Application Number: PCT/EP00/00345

(22) International Filing Date: 13 January 2000 (13.01.00)

(30) Priority Data:
60/118,400 2 February 1999 (02.02.99) US

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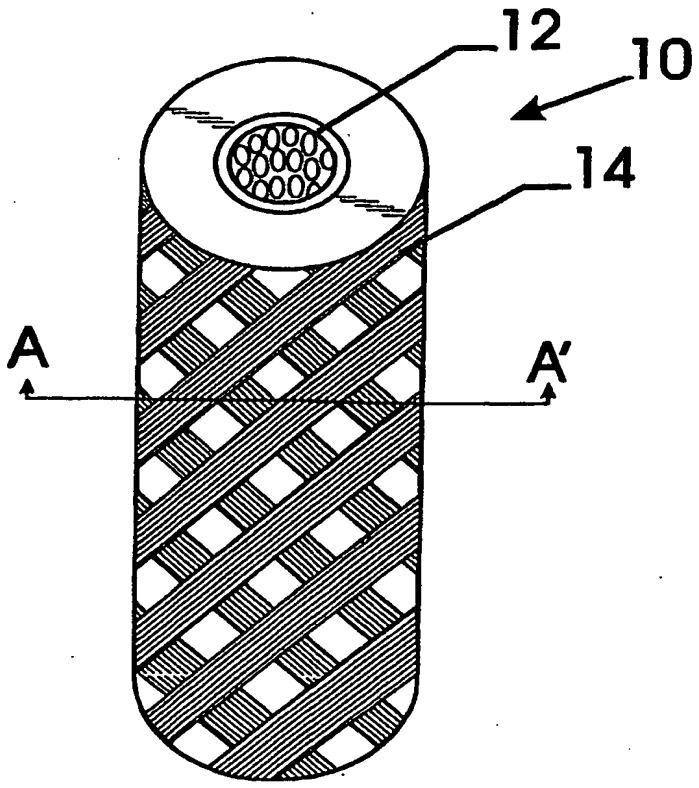
(81) Designated States: JP, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: TOW WOUND FILTER CARTRIDGE

(57) Abstract

A tow wound filter cartridge (10) comprises a permeable core (12) and one or more tows (14) wound in a helicoidally or diamond–like shaped way or serpentine–like way around the core, having a zero twist degree, in order to obtain a filter rating of below 75 micrometers. The tows may comprise metal fibers (16). Preferably the tows of the filter cartridge consist only of metal fibers.



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TOW WOUND FILTER CARTRIDGE

Field of the invention.

The present invention relates to a tow wound filter cartridge comprising a permeable core and one or more tows wound in a helicoidally or diamond-like shaped way or serpentine-like way around the core.

Background of the invention.

Tow wound filter cartridges are known as such in the art.

As a matter of example, US-A-5,679,251 discloses a tow wound filter cartridge, which comprises polyester yarns. The filter is used as a secondary oil filter in diesel engines.

Next to their filter rating, these types of filter cartridges, however, suffer from some major disadvantages.
One of the main disadvantages is that such a filter cartridge is not fit to be cleaned or back-flushed several times. These filter cartridges are used and simply discarded after their use.
Another disadvantage is that such a filter cartridge is not fit to operate in severe circumstances such as under high pressures or under high temperatures. Indeed textile filter cartridges are not stable. Textile filter cartridges swell as they become wet and the outside wraps or layers slides down the outside surfaces.

Summary of the invention.

It is an object of the present invention to provide a filter cartridge with an improved filter rating compared to the tow wound filters as known in the art.
It is another object of the present invention to provide a filter cartridge, which can be cleaned several times.

It is also an object of the present invention to provide a non-disposable filter cartridge.

It is yet another object of the present invention to provide a filter cartridge with an improved integrity and stability of the filter medium.

According to the invention, there is provided a tow wound filter cartridge comprising a permeable core and one or more tows wound in a helicoidally or diamond-like shaped way or serpentine-like way around the core in order to obtain an absolute filter rating of below 75 micrometer. The tows may comprise metal fibers and, in a preferred embodiment of the invention, the tows consist of only metal fibers. It is even so that tow wound filters as subject of the invention can be provided, retaining more than 95%, e.g. more than 99% of all particles larger than 20µm, even of all particle larger than 10µm or 5µm. Tow wound filters as subject of the invention may retain more than 95% of all particles larger than 1µm or 0.75µm.

One tow or bundle may comprise between 100 and 15000 fibers, for example 10000 or 12000 fibers. The filter may comprise more than one tow where each tow has a different number of fibers or where each tow has a different type of fibers, e.g. with fibers of a different diameter.

Tows in a cartridge as subject of the invention, have a zero twist degree, which means that the individual fibers in a tow run about parallel and untwisted one adjacent to the other. The result of this zero twist degree is that during the winding operation the tow is applied to the core in the form of a flat tape rather than an oval shaped yarn. This results in lower void volume in the filter, which in turn leaves less space for small particles to pass through. So the zero twist degree allows obtaining lower filter ratings in comparison with wound tow cartridge filters with tows having a twist.

The tows of the filter cartridge may form a plurality of layers around the core of the cartridge. Each of the layers may consist only of fibers of an

equal fiber diameter and the diameter of the fibers may vary depending upon the layer in which the tow is positioned.
In this way asymmetric filter structures may be formed by winding different fiber diameters in layers onto the core in an ascending or descending fiber diameter order.

Within the context of the present invention, the terms "metal fibers" refer to fibers which can be manufactured by abrading the upper edge of a rolled metal foil, as described in US-A-4,930,199, or by using the bundled drawing technique, as described, e.g., in the patent US-A-3,379,000, or by means of a melt extraction technique. The metal fibers have an equivalent diameter ranging between 1 µm and 100 µm, preferably ranging between 1.5 µm and 45 µm, for example between 2 µm and 30µm. The terms "equivalent diameter of a fiber" are defined as the diameter of an imaginary round fiber having the same cross-section as that of the real fiber concerned.

In a preferred embodiment of the present invention, a filter cartridge comprise or even consists of metal fibers, most preferably stainless steel fibers, e.g. of alloy AISI 302, AISI 304, AISI 316 or AISI316L.

The metal fibers may have a composition, which is resistant to high temperatures and to thermal shocks. For this purpose, they may comprise minimum amounts of Al (aluminum) and Cr (chrome). Examples of such a composition are $Fe_aCr_bAl_cY_d$. alloys such as disclosed in EP 0 157 432.

In a particular embodiment of the present invention, the magnetic properties of the metal fibers in the tows of the filter cartridge are used. Bundled-drawn stainless steel fibers are ferromagnetic, i.e. when applied in an external magnetic field, they have a relative magnetic permeability μ_r which is a number of times greater than one. Ferromagnetic materials e.g. comprise components chosen among Fe, Co, Co, Cu, Ni, ...
Usually the higher the Fe, Co, Cu or Ni contents, the more pronounced

the ferromagnetic properties. A tow wound filter cartridge with ferromagnetic fibers has the advantage of being more effective in removing magnetic and para-magnetic particles from, for example, lubricating oils. Indeed it is important that engine oil filters for internal combustion engines can remove the small iron particles which are produced by the wear cycles. By placing tow wound cartridges of this type in a magnetic field, the iron particles can be filtered out of the engine oil more effectively. This is an additional advantage of some of the invention tow wound filter cartridges in comparison with textile filters or paper filters.

In still another embodiment of the present invention the tow wound filter cartridge comprising metal fibers has been sintered, e.g. hydrogen-sintered in order to avoid fiber transfer. So the integrity of the filter medium has been increased by the sintering operation. Such a sintered version is more adapted to be used in more demanding applications such as highly loaded liquids or gases, high turbulencies and filter cartridges operating under high vibrations. The sintering operation, however, removes the ferromagnetic properties of the fibers, i.e. the relative magnetic permeability μ_r becomes one after the sintering operation.

Tow wound filters as subject of the invention, comprising mainly metal fibers are more stable, since they don't swell significantly under use, and are more resistant to higher temperatures, pressure and aggressive circumstances. It is even so that, after being cleaned several times by applying a black-flush, tow wound filters comprising mainly metal fibers maintain their filter performance to a large extend, so providing a non-disposable filter madium.

Brief description of the drawings.

The invention will now be described into more detail with reference to the accompanying drawings wherein

- FIGURE 1 shows a side view of a tow wound filter cartridge according to the invention .
- FIGURE 2 shows a zero twist tow.
- FIGURE 3 shows a radial section of a tow wound filter as subject of the invention.
- FIGURE 4 shows a detail of the section as shown in FIGURE 3.

Description of the preferred embodiments of the invention.

FIGURE 1 schematically shows a tow wound filter cartridge 10 comprising a permeable core 12 in the form of a metal cylinder with holes provided in its surface. Tows 14 of fibers 16, preferably metal fibers, have been wound in a helical or diamond-like shaped way or serpentine-like way around the core. The particular way of winding together with the number of fibers in a tow and the diameter of the fibers determines the filter rating of a filter cartridge. Several layers of windings may be put one above the other.

FIGURE 2 illustrates a zero twist tow 14 with metal fibers 16. The zero twist means that the metal fibers 16 are not twisted around each other and are arranged in more or less a parallel way.

FIGURE 3 is a radial cut of a tow wound filter as shown in FIGURE 1, parallel to the plane AA'. FIGURE 4 is a detail view of FIGURE 3. As shown in FIGURE 4, the filter has the advantage that the tow itself may easily take the form of a flat, rectangular or square ribbon and that upon winding such a tow around the core 12, volume voids 18 are avoided as much as possible so that the filter rating is decreased in comparison with filter cartridges where the tows have no zero twist.
In contrast herewith tows with a non zero twist do not take the form of a flat, rectangular or square ribbon, and remain rather circular or oval in

shape. Winding such tows with a non-zero twist always creates voids between adjacent windings.

Several embodiments of the tow wound filter cartridge according to the invention were manufactured for test purposes.
Aqueous suspensions of AC Spark Plug Fine Air Cleaner test dust were prepared.
The filters were first flushed with ten gallons of deionized water, followed by one gallon of dust suspension. After approximately three quarts of effluent had been collected, a 1 ml (milli-liter = 1/1000 liter) sample was passed through a 0.45 micrometer (34 mm diameter) Millipore filter. Following filtration, the filters were dried and examined using an Olympus CH-2 Microscopic, equipped to perform light, phase, contrast, dark field, and polarized light microscopy. Examination was performed at 1000X.
Ten fields per filter were counted.
Particles were sized, using the Olympus Reticule (graduated from 0 micrometer to 100 micrometer), and percentages calculated as well as total number of particles per filter (10 ml of sample).

Table I summarizes the results.

Other test samples were subjected to similar tests, aiming at even lower filter ratings. The tests were done under ambient temperature using water and ISO A2 (fine) contamination. As can be found in table II, a retention of more than 95% of the particles larger than 1µm or even of particles larger than 0.75µm can be obtained using zero twist tow wound filters.

Table I

			Filter #1 Filter rating 50 µm		Filter #2 Filter rating 25 µm		Filter #3 Filter rating 10 µm	
	Internal diameter (inch)		1.07 (27.178 mm)		1.07 (27.178 mm)		1.07 (27.178 mm)	
	Outer diameter (inch)		1.96 (49.784 mm)		2.10 (53.34 mm)		1.74 (44.196 mm)	
	Weight (Ozs)		16.7 (473.445 g)		24.2 (686.07 g)		15.3 (433.755 g)	
Particle size range (µm)	Filter charge							
	%	Particles per ml	Particles per ml	% reduction	Particles per ml	% reduction	Particles per ml	% reduction
< 1	49.6	1134400	345420	69.6	49980	95.6	61202	94.6
1-5	18.3	417600	200640	51.9	31752	92.4	9798	97.7
5-10	10.4	238400	19380	91.9	2268	99.0	0	100
10-20	8.6	196000	4560	97.7	0	100	0	100
20-50	10.6	243000	0	100	0	100	0	100
> 50	2.5	56600	0	100	0	100	0	100
Total particles		2286000	579000		84000		71000	
% reduction (all sizes)			75.1		96.3		96.9	

TABLE II		Particle size							
sample	Number particles	1-2 (µm)	2-5 (µm)	3-4 (µm)	4-5 (µm)	5-7 (µm)	7-10 (µm)	10-12 (µm)	>12 (µm)
Filter rating 10µm; 11µm fibers	Upstream	96779	34176	33581	16080	8554	3963	729	829
	Downstream	14725	3557	2261	569	113	7	1	1
	Retention (%)	84.78	89.59	93.40	96.46	98.68	99.83	99.86	99.88
Filter rating 10µm; 8µm fibers	Upstream	96656	33878	33701	1621	8809	4106	744	816
	Downstream	1461	205	91	23	4	1	0	0
	Retention (%)	98.49	99.39	99.73	98.60	99.95	99.98	>99	>99
		0.5-0.6 (µm)	0.6-0.75 (µm)	0.75-1 (µm)	1-2 (µm)	2-3 (µm)	3-4 (µm)	4-5 (µm)	>5 (µm)
Filter rating 10µm; 8µm fibers	Upstream	62005	82350	87681	49795	10347	6059	3177	3963
	Downstream	9323	6499	3659	1029	53	13	5	2
	Retention (%)	84.96	92.11	95.83	97.93	99.49	99.79	99.85	99.95

CLAIMS

1. A tow wound filter cartridge comprising a permeable core and one or more tows wound in a helicoidally or diamond-like shaped way around said core characterized in that said tows have a zero twist degree.

2. A filter cartridge according to claim 1 wherein said tows comprise metal fibers.

3. A filter cartridge according to claim 1 wherein said tows consist of metal fibers.

4. A filter cartridge according to claim 1 or 3, wherein said tow wound filter cartridge has an absolute filter rating of below 75 micrometer.

5. A filter cartridge according to claim 1 or 2, wherein said tow wound filter cartridge retains 95% of all particles larger than 1µm.

6. A filter cartridge according to any one of claims 2 to 5 wherein said metal fibers are ferromagnetic fibers.

7. A filter cartridge according to any one of claims 3 to 5 wherein said cartridge has been sintered in order to avoid fiber transfer.

8. A filter cartridge according to any one of the preceding claims wherein said fibers have a diameter ranging from 1 micrometer to 100 micrometer.

9. A filter cartridge according to any one of the preceding claims wherein said tows form a plurality of layers.

10. A filter cartridge according to claim 9 wherein each of said layers only consists of tows with fibers of an equal fiber diameter.

11. A filter cartridge according to claim 10 wherein a first of said layers consists of tows with fibers of a first fiber diameter, wherein a second of said layers consists of tows with fibers of a second fiber diameter, said first fiber diameter being different from said second fiber diameter.

12. A filter cartridge according to claim 11 wherein said second fiber diameter is greater than said first fiber diameter and wherein said second of said layers is positioned closer to the core than said first of said layers.

13. A filter cartridge according to claim 11 wherein said second fiber diameter is greater than said first fiber diameter and wherein said first of said layers is positioned closer to the core than said second of said layers.

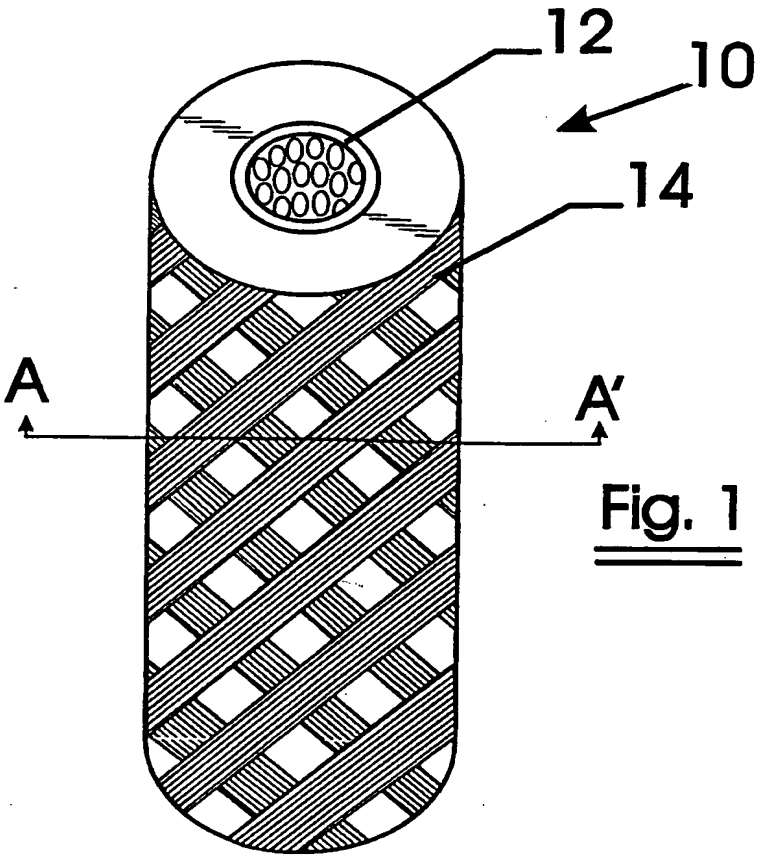

Fig. 1

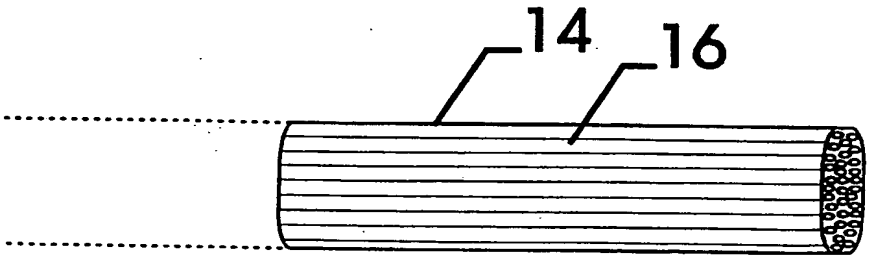

Fig. 2

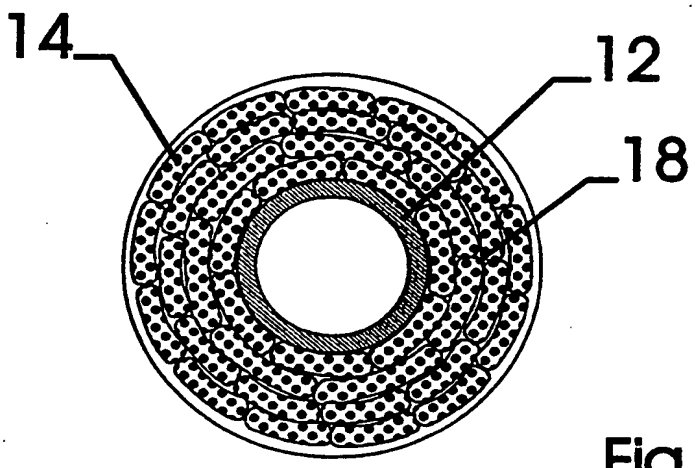

Fig. 3

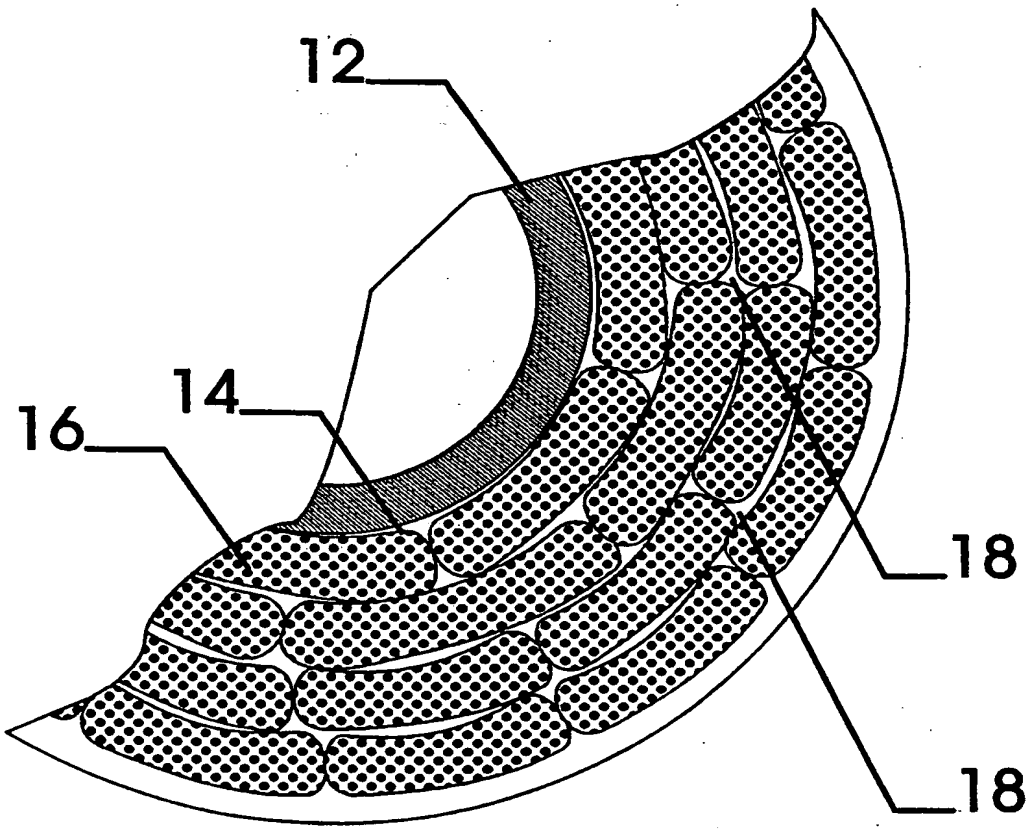

Fig. 4

INTERNATIONAL SEARCH REPORT

Intern al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B01D39/20 B01D29/21

According to International Patent Classification (IPC) or to both national classification and IPC

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 3 065 856 A (GOLDMAN J.H.) 27 November 1962 (1962-11-27) column 5, line 7 - line 30; figures 11-13	1,9-11

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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